8. DISCUSSION — INTEGRATING BIOLOGICAL, ENGINEERING, AND OPERATIONAL CONSIDERATIONS

8.1 FINDINGS

During the Phase I assessment process, we determined that there are a range of options and opportunities for providing fish passage and potentially reestablishing populations of anadromous salmonids in some tributaries of the five Yakima River basin reservoirs. Some combinations of passage options and associated biological benefits are more feasible than others. Costs vary widely among options, especially for downstream passage of juvenile fish. All five reservoirs have some tributary habitat that would be available if passage were provided at the dams. However, the amount and quality of the habitat varies considerably from reservoir to reservoir. The effective passage window also varies considerably from one option to another and would significantly affect the feasibility of a given proposal.

From our initial assessment, it appears that some form of upstream and downstream passage is technically feasible at all the storage projects. Passage at some would be much more expensive in relation to available habitat than at other locations.

Another factor to consider is that optimizing fish passage at one storage project might require changing operations at another in order to ensure continuity of water delivery obligations and other Yakima Project purposes. However, for purposes of this Phase I assessment, each project was considered separately, based on existing operational considerations and constraints.

The assessment team developed a procedure for comparing the passage projects, which considered engineering aspects, habitat, and system operational constraints. This provided a framework to understand the various upstream and downstream passage options combined with a preliminary assessment of the tributary habitat that would be potentially available to anadromous salmonids. Initially, the team used “stream miles potentially accessible upstream” from each reservoir; these were derived from the environmental factors matrices compiled by the fisheries subteam (shown as appendix C). We noted discrepancies in stream length reported from various published sources and used the experience and professional judgment of the fisheries biologists to determine potentially accessible stream miles up to impassable barriers.

The estimated costs of the several upstream and downstream passage options were divided by the number of stream miles to determine the cost per mile for each upstream and downstream passage option at each storage project. Upstream comparisons are shown in Table 8-1 and downstream comparisons in Table 8-2. These values were summed where both upstream and downstream options were available and then compared in Table 8-3. For ease of comparison, the estimates were rounded up or down to the nearest $100,000 per mile.

Table 8-1. Estimated cost of three upstream fish passage options at Yakima River basin storage dams; costs per mile, based on estimated construction costs; and miles of accessible tributary habitat

Project	Newly accessible habitat		Estimated cost for upstream passage ($1 millions)			Cost per mile for upstream passage ($1 millions)		
	Miles	Assumed quality	Opt. 1 Trap-and-haul	Opt. 2 Fish ladder w/ pumped flow	Opt. 3 Fish ladder w/ gravity flow	Opt. 1	Opt. 2	Opt. 3
Keechelus	13.80	Good	7.0	8.5	—	0.5	0.6	—
Kachess	2.35	Good	7.0	8.5	—	3.0	3.6	—
Cle Elum	29.40	Good	7.0	8.5	—	0.2	0.3	—
Bumping	6.00	Good	7.0	—	11.0	1.2	—	1.8
Rimrock	36.80	Good	7.0	—	—	0.2	—	—

Table 8-2. Estimated costs of four downstream fish passage options at Yakima River basin storage dams and costs per mile based on estimated construction costs and miles of accessible tributary habitat

Project	Newly accessible habitat		Estimated cost for downstream passage (in $1 millions)				Cost per mile for downstream passage ($1 millions)			
	Miles	Assumed quality	Opt. 1 Spillway modifi-cations	Opt. 2 New spillway	Opt. 3 Fish collection barge	Opt. 4 New outlet works	Opt. 1	Opt. 2	Opt. 3	Opt. 4
Keechelus	13.80	Good	4.5	8.0	11.0	25.0	0.3	0.6	0.8	1.8
Kachess	2.35	Good	5.0	10.0	11.0	25.0	2.1	4.3	4.7	10.6
Cle Elum	29.40	Good	2.2	10.0	11.0	25.0	0.1	0.3	0.4	0.9
Bumping	6.00	Good	1.7	4.6	11.0	20.0	0.3	0.8	1.8	3.3
Rimrock	36.80	Good	2.5	42.0	11.0		0.1	1.1	0.3	—

Table 8-3. Estimated construction costs per mile of combined upstream and downstream passage for three upstream passage options and four downstream passage options

(Numbers reflect summed cost per mile in $1 millions, calculated from tables 8-1 and 8-2).

Upstream options	Downstream options	Keechelus	Kachess	Cle Elum	Bumping	Rimrock
1. Trap-and-haul	1	0.8	5.1	0.3	1.5	0.3
	2	1.1	7.3	0.6	1.9	1.3
	3	1.3	7.7	0.6	3.0	0.5
	4	2.3	13.6	1.1	4.5	—
2. Fish ladder w/ pumped flow	1	1.0	5.7	0.4	—	—
	2	1.2	7.9	0.6	—	—
	3	1.4	8.3	0.7	—	—
	4	2.4	14.2	1.1	—	—
3. Fish ladder w/ gravity flow	1	—	—	—	2.1	—
	2	—	—	—	2.6	—
	3	—	—	—	3.7	—
	4	—	—	—	5.2	—

- No upstream passage Opt. 2 at Bumping Lake Dam and Tieton Dam
- No upstream passage Opt. 3 at Keechelus, Kachess, Cle Elum and Tieton dams.

In Table 8-3, a lower number indicates a lower passage construction cost per mile of stream habitat if O&M costs and duration of passage window are not considered. At some storage projects, various upstream and downstream passage options were not available or not considered to be feasible, so only those cells in the table that include both upstream and downstream passage options were compared in this Phase I assessment. For example, Tieton Dam is not included in some comparisons because early in the assessment process we recognized that installing a fish ladder there would be prohibitively expensive.

Other factors not considered in detail here but that should be evaluated in Phase II are the long-term O&M costs associated with a trap-and-haul passage option for adult salmonids versus the costs of maintaining pumped or gravity flow in a ladder.

A third consideration not reflected in Table 8-3 is the downstream migrant passage window that each of the options would encompass. The hydrographs for the five reservoirs (figures 1 through 5 in appendix D) show that each option provides a different window of passage. For example, at Cle Elum Dam, a new spillway would provide a much broader window of passage than spillway modification, but at a higher cost. In drier years such as 2001, a new spillway still would not provide for season-long, volitional, juvenile fish passage.

Another consideration not reflect in Table 8-3 is that juvenile outmigrants passing over the Tieton Dam spillway might encounter severe conditions that could cause substantial injury and result in some level of mortality. Further study would be needed to evaluate the degree of injury and mortality on juvenile outmigrants.

In Table 8-3, we see that for all storage projects, the lowest initial cost per mile (that is, without considering passage window or O&M costs) for anadromous salmonids to access suitable habitat is trap-and-haul for adult upstream passage and spillway modification for juvenile downstream passage. Cle Elum Dam and Tieton Dam have the lowest overall estimated construction costs per mile of stream habitat. These were followed by Keechelus, Bumping, and Kachess dams. In considering fish ladders for adult upstream passage (upstream options 2 and 3), Cle Elum Dam with spillway modifications for juvenile outmigrants is substantially less than the other passage projects in cost per mile (table 8-3).

Cle Elum Lake is the largest reservoir in the Yakima River basin, and it has a substantial amount of tributary and mainstem habitat upstream from the reservoir that would be accessible for anadromous salmonids and bull trout if passage were provided there. Generally, this habitat is in good condition and some is pristine since much of the watershed lies within the Alpine Lakes Wilderness Area. Considerable research has been conducted on the Cle Elum watershed, especially in relation to the restoration of sockeye salmon (Flagg et al. 2000).

8.2 ADDITIONAL ISSUES AND CONCERNS

The team encountered numerous issues and concerns that were beyond the scope of this Phase I assessment. These issues and concerns as well as identified data gaps will need to be addressed in later phases of this effort. As a followup to this final Phase I report, Reclamation will draft a Phase II proposal to provide the context for discussion by the entire assessment team in early spring 2003. Some of the items and issues that Reclamation identifies as pertinent and appropriate for Phase II are discussed below. These and other issues will be developed in greater detail in the draft Phase II proposal.

Numerous data gaps were noted, especially related to tributary habitat quality. Data gaps relate directly to the feasibility of providing passage for anadromous salmonids and bull trout and the expected increase in fish production that would be achieved in the newly accessible habitat.

Several issues and concerns were raised regarding the engineering feasibility of some of the concepts proposed in this Phase I report. One concern is the potential for increased seepage that could pose a dam safety concern for the passage concepts that require excavating channels upstream from the dams. This issue was discussed previously in regard to Cle Elum Dam, but the issue would be valid at all the dams. It would require further study and possibly geotechnical investigations and analysis.

Another concern is in regard to the orifice type of ladder proposed for Bumping Lake Dam, which was modeled after the fish ladder at Easton Dam. The Bumping Lake Dam ladder, under some reservoir conditions, would require fish to sound and pass through somewhat deeper orifices than at Easton Dam ladder. Further biological and hydraulic evaluations should be made to determine if the conditions in the ladder would meet criteria for passage of the targeted fish species.

For the passage concepts at the taller dams that use fish ladders with pumped flow, the length of the ladders and the number of pools may be a concern for some species because there is a risk of fish not swimming the height of these fishways. This may require further investigation and review of existing tall facilities with ladders.

The severe winter conditions at the dams and the potential for ice formation on the reservoirs is a concern for the operation of passage concepts. It is not completely known at what conditions the facilities may cease to function. This is likely the most critical for the fish collection barge and for concepts that require personnel to operate. Ice formation and the inability to operate would limit the passage window. An additional concern, particularly for downstream passage concepts, is problems with debris. The net used for the fish collection barge may be the most susceptible component to problems with debris. A site-specific assessment of potential debris loads is recommended.

One pertinent issue is the potential for injury to and/or mortality of outmigrating juveniles for each of the several downstream passage options, especially spillway options. Long spillways with shallow depth and high water velocity such as exist at Tieton Dam may injure or kill juvenile or adult fish.

An adequate monitoring and evaluation program must be an integral part of any fish passage and restoration program. Appropriate sampling must be conducted to evaluate adult use and passage, and numbers of outmigrating juvenile must be assessed. The measure of success of the fish passage program must be developed, including a discussion of whether there are trade-offs between upstream passage, downstream passage, and habitat restoration, including off-site habitat improvements in lieu of passage. A decision must be made on whether interim and long-term population targets for each subbasin are appropriate or necessary as part of measuring success. A longer-term consideration is to determine if passage has contributed to the basin-wide salmonid recovery efforts.

Several other issues include whether there would be additional competition for limited resources among the restored populations of anadromous salmonids and resident fish; how best to expedite restoration efforts for coho and sockeye salmon where they occurred historically; the extent of predation in the tributaries or lakes and/or poaching on adult or juvenile anadromous salmonids.

As reintroduction and restoration efforts proceed, the potential ecological interactions within the systems will need to be considered and evaluated, especially since the lakes are oligotrophic with limited production of prey items. Fertilization may be required to boost primary and secondary production and enhance the food web in the lakes to sustain the added demands for food from rearing sockeye salmon juveniles.